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PORTO RICO SWEETPOTATOES

During Marketing

—A Progress Report—

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FUNGICIDAL CONTROL OF DECAY IN PORTO RICO SWEETPOTATOES DURING MARKETING

—A Progress Report—

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SUMMARY

Because spoilage losses of sweetpotatoes are high during marketing, tests were conducted to determine whether fungicidal treatment could reduce black rot and soft rot of this commodity.

Eight chemicals were tested for control of the two rots on Porto Rico sweetpotatoes. Peracetic acid, sodium o-phenylphenate (SOPP), propyl-N-phenylcarbamate, isopropyl-N-(3-chlorophenyl) carbamate (CIPC), and the sodium and calcium salts of propyl p-hydroxybenzoate gave promising control of these diseases in screening tests.

SOPP (0.5 to 1.0 percent) usually reduced black rot and soft rot 75 percent or more when applied as a dip or spray, but caused injury when applied at 1.3 to 1.5 percent. Control of black rot and soft rot decreased rapidly at concentrations below 0.4 to 0.5 percent, unless treating temperatures were raised. Discoloration of skinned areas on noncured roots treated with 0.5 to 1.0 percent solutions was reduced by rinsing, and nearly eliminated by addition of sodium sulfite.

Residue of SOPP was less than 10 p.p.m. (expressed as o-phenylphenol) in all determinations, even on roots treated with 1.3 to 1.5 percent solutions. Rinsing reduced residues. Neither rinsing nor addition of sulfite measurably altered the control of black rot or soft rot.

Black rot was controlled and soft rot reduced by peracetic acid in a wide range of concentrations, temperatures, and durations of treatment. Peracetic acid did not cause injury or discoloration, and, being unstable, apparently left no residue 15 minutes after treatment. It was not tested further because it did not control soft rot as well as some other chemicals and because of the difficulty of handling an explosive compound. Additional tests are needed for the other chemicals showing good results in the screening tests.

At present, the tolerance for sodium o-phenylphenate (SOPP) on sweetpotatoes is 15 p.p.m.

No tolerances have been established for the postharvest use on sweetpotatoes of the other chemicals discussed in this report; and they should not be used unless a tolerance for their use is established.

INTRODUCTION

Spoilage losses of sweetpotatoes are high during marketing (32).[1] Preliminary tests indicated that fungicidal treatment might reduce decay due to soft rot (Rhizopus sp.) after preparation for marketing (16). Data supplied by the manufacturers or already in the Federal Register indicate that the chemicals used in the studies reported here have been approved or have a reasonable chance for approval for postharvest use on some commodities. Therefore, tests were conducted with Porto Rico sweetpotatoes to determine the potential of these chemicals for controlling black rot and soft rot. The Food and Drug Administration has approved a tolerance for a residue of 15 p. p. m. of sodium o-phenylphenate (SOPP), expressed as o-phenylphenol, in or on sweetpotatoes (Federal Register, p. 10454, Oct. 25, 1960).

METHODS

Usually roots were obtained from commercial sweetpotato storage houses after they had been cured. Some roots were cured and then held in refrigerated storage at 60° F. for several weeks. In a few tests, roots were treated immediately after harvest.

To study the development of soft rot under laboratory conditions, roots were washed and injured by badly bruising one end of each sweetpotato and breaking off the other end. After immersion for about 15 to 60 seconds in the treating solutions (at 60 to 70° F.), the unrinsed roots were placed in manila paper bags, 10 roots to a bag and 4 bags to a treatment. In some tests, the treating solutions were heated as high as 120° before roots were immersed. After 7 days at 60° F., the soft rot that started at the bruised or broken ends was determined. The sweetpotatoes were not inoculated. A holding temperature of 60° was selected because it represents temperatures often encountered in transit during the winter (15) and favors rapid development of soft rot.

To study the development of soft rot under semicommercial conditions, two methods were used. In one method, roots were run through a small commercial washer and then, after free water was drained off, through a dipping tank onto a roller conveyor, and were deposited in baskets. Roots remained in the solutions about 20 seconds. A series of nozzles was mounted over the roller conveyor at a point beyond the treating tank, so that the roots could be rinsed with water from 1 or 2 nozzles in succession, or not rinsed at all. The nozzles produced a fine spray while delivering about 1 gallon per minute at 10 pounds pressure. About 15 seconds elapsed between the time roots left the treating solution and the time they reached the rinse.

The second semicommercial method employed the water-wax applicators used in commercial packing houses for coloring and waxing roots during grading. Usually the recirculated treating solution was sprayed on the roots as they passed under a single row of nozzles mounted over the roller conveyor. This wet the roots completely. A water rinse was applied, when desired, by holding a single row of spray nozzles over the conveyor at a point beyond the water-wax applicator. Roots treated in this manner were usually hauled by panel truck to Raleigh, N. C. (30 to 50 miles), and stored at 60° F. for 7 days. In two instances, roots were shipped in commercial truckloads to New York, N. Y., where they were examined for the development of soft rot after 1 week at 70° F.

Roots used in the semicommercial methods of application were injured only as in normal handling and grading practices. Three bushels of roots were used in all holding tests except the two that were shipped to New York. In those, 2 bushels from each treatment were shipped and 2 were held at the shipping point.

To study the development of black rot under laboratory conditions, cultures of the black rot fungus were maintained on pieces of sweetpotato roots. The fungus was allowed to grow until spore masses exuded from the perithecia, and then the pieces of roots were scraped and the scrapings macerated with water in a high-speed blendor. A drop of wetting agent (Tween 20) was added to aid dispersion. After filtering through three or four layers of cheesecloth, the water suspension was used to inoculate freshly cut pieces of roots or whole, injured roots. The inoculum was added to the treating solutions in which the pieces of roots were dipped. The inoculated roots or pieces of roots were placed in moist chambers and held at 80° to 85° F. for 3 to 10 days, depending on the rapidity of black rot development. In other tests, inoculum was heat treated by adding 1 ml. of inoculum to 10 ml. of water or to the treating solution, which had been heated to the required temperature in metal tubes in a water bath. After treatment at elevated temperature, the tubes of inoculum were cooled rapidly to 60° in running water. The cooled inoculum was placed on freshly cut pieces of roots which were held at 80° to 85° in moist chambers as above.

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[1] Underlined figures in parentheses refer to items in Literature Cited, p. 16.

To simulate the potential buildup of black rot inoculum in commercial treating tanks and on grading equipment, inoculum was added to the dipping tank before several of the treatments were made, as described for the tests with soft rot. In these instances, the roots were held beyond the initial period allowed for soft rot to develop, and were reexamined for black rot. Roots treated with the commercial water-wax applicators also were held after the initial period allowed for soft rot to develop, because black rot was recovered in several instances from them. Holding temperatures varied from 70° to about 80° F. and the holding period from 10 to 21 days, to allow time for black rot to develop.

After preliminary tests had established that essentially pure sodium o-phenylphenate in water would control both soft and black rots to a considerable degree, several commercial formulations and modifications were tested. Inhibitors of discoloration and chemical injury, developed for other commodities (9, 13, 21, 23), were tested for reducing discoloration and chemical injury to sweetpotatoes.

Soft rot is reported as the percentage of roots developing this decay. Black rot also is reported as the percentage of roots showing black rot spots when whole roots were used, but, in the tests with inoculated pieces of roots, it is reported as the number of black rot spots or as the percentage of the surface covered with growth of the organism.

After the holding periods to allow soft rot and black rot to develop, duplicate 10-pound samples of sound sweetpotatoes were sent to the manufacturer and analyzed for residue of o-phenylphenol (7, 30). Peracetic acid residues were determined by the author with methods supplied by the manufacturer (2). Residue analyses were not made for other chemicals.

The following abbreviations will be used to indicate the chemicals tested: Sodium o-phenylphenate (SOPP), peracetic acid (PAC), beta cyanoethyl-N-phenylcarbamate (CNPC), propyl-N-phenylcarbamate (PPC), isopropyl-N-(3-chlorophenyl) carbamate (CIPC), sodium and calcium salts of propyl p-hydroxybenzoate (PKS and PKC, respectively), and sodium benzoate (SB). All chemicals were used as solutions in water, except the carbamates, which were used as emulsifiable solutions of xylene, and some water-wax formulations of SOPP. Concentrations are reported as percentages of chemical calculated as grams per 100 ml. of treating solution. PKS and PKC are reported as percenages of propyl p-hydroxybenzoate (PK). Data for SB are included for comparison with PK.

RESULTS

Screening tests (tables 1 and 2) showed that soft rot and black rot were reduced greatly in roots treated with 0.5 and 1.0 percent SOPP, CNPC, and PKS, with 1.0 percent CIPC and PKC, and with concentrations of PPC as low as 0.125 percent (soft rot) or 06 percent (black rot). PAC was especially effective in controlling black rot, and it reduced soft rot as well as some of the other chemicals. SB was ineffective in reducing either soft rot or black rot.

More soft rot developed and it was more difficult to control in bruised ends of roots than in broken ends (table 1).

With solutions of SOPP at concentrations of 0.25 and 0.5 percent, waiting 60 minutes after adding inoculum before immersing root pieces gave better control of black rot than waiting only 10 minutes (table 2).

TABLE 1.--Percentage of soft rot in bruised or broken Porto Rico sweetpotatoes after treatment with different concentrations of eight chemicals[1]

Chemical[2] and concentration	Soft rot in bruised root ends at indicated concentration					Soft rot in broken root ends at indicated concentration				
Concentration (percent)	0	0.125	0.25	0.5	1.0	0	0.125	0.25	0.5	1.0
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
SOPP............	68	45	18	3	0	15	8	0	0	0
PAC.............	70	23	18	25	15	10	3	5	5	3
CNPC............	75	40	40	20	5	8	13	15	3	0
CIPC............	53	48	25	23	10	5	15	8	0	0
PPC.............	33	0	0	0	0	8	3	0	0	0
PKS.............	60	45	20	5	3	10	10	5	0	0
PKC.............	33	13	18	5	5	10	15	13	13	3
SB	73	85	85	90	85	8	8	3	5	5

[1] Based on 40 roots for each chemical and concentration except SOPP for which the average of 3 tests is reported (120 roots). Roots held 7 days at 60° after injuring and treating.

[2] Full name of these chemicals given on page 5.

TABLE 2.--Black rot on pieces of Porto Rico sweetpotatoes after immersion in solutions of different concentrations of eight chemicals containing black rot inoculum[1]

Chemical and concentration	Number of spots for indicated concentration					
Concentration (percent)	0	0.06	0.125	0.25	0.5	1.0
	Number	Number	Number	Number	Number	Number
SOPP.............	A[2]	A	A	8	3	0
SOPP[3]............	A	A	A	5	0	0
PAC	A	0	0	0	0	0
CNPC.............	A	A	A	7	0	0
CIPC.............	A	A	38	35	36	15
PPC..............	A	1	3	3	3	0
PKS..............	A	A	A	8	7	4
PKC..............	A	A	A	10	6	0
SB...............	A	A	A	A	A	A

[1] Inoculum added to treating solutions 10 minutes before immersing root pieces, except as noted. Data based on 2 root pieces per chemical and concentration; held 3 days in moist chambers at 80° to 85° F.

[2] A = abundant growth, usually too many spots to be counted accurately.

[3] Inoculum added 60 minutes before immersing root pieces.

SOPP caused noticeable discoloration, especially on skinned areas of freshly harvested roots. The discoloration, at first green, often darkened to become almost black in some cases. Discoloration of cured roots, which skinned very little, was usually not objectionable. Supplementary tests, for which data are not shown, demonstrated that some sweetpotato varieties discolor more than others when treated with SOPP. The pattern followed that listed by Scott and Kattan for difference in catechol oxidase; that is, Allgold, Goldrush, and Kandee developed much less discoloration than Porto Rico (26).

The ultraviolet absorption spectrum for samples extracted and measured by the methods of Lieberman, Craft, and Wilcox (17) was similar to that shown in their work for chlorogenic acid, indicating that the same or a similar mechanism is involved in discoloration of sweetpotato roots treated with SOPP. This agrees with the statement of Geissman (6) that "one of the noteworthy properties of chlorogenic acid is its reaction with ammonia in the presence of air with the formation of a green (in the ammonical solution) substance called 'viridic' or 'viridinic acid.'" Chlorogenic acid has been associated with discoloration of sweetpotatoes by other workers (25, 31).

Modifying the treating solution with chemicals which helped control chemical injury in citrus (9, 18, 21) did not reduce discoloration (table 3). The data in table 3 indicate that the concentration of free o-phenylphenol, which decreases with increase in pH (18), was not associated with discoloration of sweetpotatoes. Commercial formulations with water or water-wax did not control discoloration except in one instance; decay control was reduced in this case (formula 101-A) (table 4).

TABLE 3.--Soft rot and discoloration of Porto Rico sweetpotatoes immersed in different formulations of 1-percent sodium o-phenylphenate and held 7 days at 60° F.

Treating solution, additive, or formula	pH	Soft rot at bruises		Soft rot at breaks		Average discoloration
		Test 1	Test 2	Test 1	Test 2	
		Percent	Percent	Percent	Percent	
None (water)............	6.7	100	100	40	24	None
1% SOPP with--						
Nothing added..........	10.6	18	3	0	0	Slight
Hexamine, 19.0 g. per gal..............	10.8	38	0	0	0	Slight
Sodium hydroxide, 9.4 g. per gal.......	12.0	10	-	0	-	Moderate
Sodium silicate, 22.4 g. per gal......	11.7	3	0	0	0	Slight
37% formaldehyde, 8.4 ml. per gal......	10.8	20	3	0	0	Slight

TABLE 4.--Effect of adding 2-percent sodium sulfite to commercial sodium o-phenylphenate treating solutions on control of soft rot, black rot, and discoloration of Porto Rico sweetpotatoes

Treating solution	pH		Soft rot[1] in bruises		Soft rot[1] in breaks		Black rot spots[2]		Discoloration[3]	
	No sulfite	Sulfite	No sulfite	Sulfite	No sulfite	Sulfite	No sulfite	Sulfite	No sulfite	Sulfite
			Percent	Percent	Percent	Percent	Number	Number		
Stopmold B[4]............	10.8	11.0	0	0	0	0	2	3	+	0
Stopmold C[4]............	11.4	11.4	0	0	0	0	7	4	++	0
Britex F[5]..............	9.5	9.7	0	0	0	0	14	16	++	0
#548[5]..................	11.4	11.6	0	0	0	0	5	6	++	0
101-A[6].................	8.6	8.8	60	33	3	0	38	42	+	0
Water (No SOPP).........	6.7	9.2	35	45	5	8	54	60	0	0

[1] Soft rot based on decay in 40 roots after 7 days at 60° F.

[2] Black rot based on growth of organism on 2 root pieces per treatment, inoculum added 10 minutes before immersing pieces, incubated 7 days at 80°.

[3] 0 = none, + = slight and ++ = moderate discoloration.

[4] Supplied by Orchard Supply Dist., Wenatchee, Wash.

[5] Supplied as water-wax emulsions by Brogdex Co., Pomona, Calif.

[6] Supplied as water-wax emulsion by American Machinery Corp., Orlando, Fla.

Of several materials tried (sodium sulfite, thiourea, ascorbic acid, citric acid, hydroquinone, 1-cysteine, triethanolamine), sodium sulfite gave the best control of discoloration, confirming results with prepeeled Irish potatoes (1, 22), which also contain chlorogenic acid and related phenols (5), and with prepeeled sweetpotatoes (27). Addition of 2 percent sodium sulfite controlled discoloration in all formulations without affecting control of decay as might be expected in alkaline media (12). The addition of sodium sulfite had no apparent effect on the water formulations, but caused flocculation of the water-wax emulsions, which could be restored only temporarily by stirring. Flocculation did not reduce the effectiveness of control when solutions were agitated. Usually less than 2 percent sodium sulfite was needed to control discoloration. Concentrations of sodium sulfite higher than that needed to control discoloration bleached skinned areas.

As reported earlier (16), brief rinsing did not reduce the control of soft rot, but rewashing roots treated with 1 percent SOPP substantially reduced control (table 5). Brief rinsing reduced the amount of discoloration of skinned surfaces. These results are similar to those reported for citrus (10, 18).

The black rot fungus in sweetpotato roots has been killed at 110° F. within 24 hours (14). This fungus could not be recovered from inoculum held at 115° for 5 minutes or at 120° for 1 minute (table 6). This verifies the sensitivity of the fungus to heat alone.

TABLE 5.--Effect of rinsing and washing following treatment with 1-percent sodium o-phenylphenate on soft rot control of Porto Rico sweetpotatoes

Treatment	Soft rot at bruises	Soft rot at breaks
	Percent	Percent
Nonrinsed	38	0
Rinsed 5 seconds	35	0
Rewashed	63	30
Check (nontreated)	100	20

TABLE 6.--Effect of heating the inoculum on infectivity of black rot spores[1]

Temperature and time of heat treatment	Percentage of cut surface covered by black rot fungus when inoculum had been treated for indicated time in minutes			
Time (minutes)	1	5	10	30
Temperature (°F):	Percent	Percent	Percent	Percent
95	100	100	100	100
100	100	100	100	100
105	100	100	100	100
110	50	33	25	10
115	20	0	0	0
120	[2] 0	0	0	0
135	[2] 0	0	0	0
160	0	0	0	0

[1] Incubated 3 days at 80° F. in moist chambers.
[2] Some fungus growth visible but black rot not recovered.

An increase in temperature of SOPP treating solutions increased the control of black rot and soft rot (table 7). No soft rot developed following a 1-minute treatment at 90° F. with 0.125-percent SOPP, and no black rot developed following treatment with 0.25-percent SOPP at this temperature. Control was as good or better after treatment at 120° as at 90°, but fumes of the warmer SOPP solution were objectionable to workers. These data on effect of temperature may explain why a concentration of 0.4 percent SOPP has been reported to be too low to control black rot, if the treatment had been carried out at a temperature of 60° or lower (24).

TABLE 7.--Black rot and soft rot on Porto Rico sweetpotatoes as affected by temperature of treating solution and concentration of sodium o-phenylphenate

Temperature and concentration of treating solution	Number of black rot spots for indicated concentration of SOPP[1]				Soft rot for indicated concentration of SOPP[2]			
Concentration (percent)	0	0.125	0.25	0.5	0	0.125	0.25	0.5
Temperature (°F):	Number	Number	Number	Number	Percent	Percent	Percent	Percent
60.............	10	11	4	1	60	35	10	0
90.............	16	6	0	0	28	0	0	0
120.............	1	0	0	0	23	0	3	0

[1] Inoculum added to treating solutions to produce indicated concentration. After the inoculum was heat treated 1 minute at indicated temperature and cooled, it was applied to fresh cut surfaces of roots. Data represent number of spots on 2 root pieces after 3 days at 80° F. in moist chambers.

[2] Bruised roots were immersed 1 minute in solutions of SOPP, drained and cooled, then held 7 days at 60° F. Data represent the average percentage of roots developing soft rot in two tests involving 40 roots for each concentration and temperature.

A similar test with black rot, using PKS as the fungicide, showed that increasing concentration or temperature of the treating solution gave greater decay reduction (table 8).

TABLE 8.--Black rot on Porto Rico sweetpotatoes as affected by temperature of treating solution and concentration of propyl p-hydroxybenzoate (PK)

Temperature and concentration of treating solution	Number of black rot spots for indicated concentration of PK[1]:				
Concentration (percent)	0	0.125	0.25	0.5	1.0
Temperature (° F):	Number	Number	Number	Number	Number
60.........................	14	14	8	7	1
90.........................	14	10	10	5	1
120.........................	0	2	5	1	0

[1] Inoculum added to treating solutions to produce indicated concentration. The treating solution containing inoculum was held 1 minute at the indicated temperature, then cooled and applied to fresh cut surfaces of roots. Data represent number of spots on 2 root pieces after 3 days at 80° F. in moist chambers. The sodium salt of PK was used.

PAC controlled black rot completely at all temperatures, concentrations, and treatment times (table 9). Soft rot was reduced to about one-third of that on nontreated roots, except in tests where 0.1 percent PAC solution was heated to 130° F., when soft rot in bruised root ends was reduced to about one-ninth of that in check roots. This decrease appears to have been due to the effect of temperature only (table 7). PAC decomposes rapidly (2), and even though no residue could be detected on roots 15 minutes after treatment in these tests, this material cannot be recommended at this time because it is considered to be a toxic chemical.

TABLE 9.--Soft rot and black rot on Porto Rico sweetpotatoes as affected by time and temperature of treating solution and concentration of peracetic acid (PAC)

Temperature of treating solution	Concentration of PAC	Treatment period	Black rot[1]	Soft rot at:[2]	
				Bruises	Breaks
°F.	Percent	Minutes	Percent	Percent	Percent
65	0	1	100	75	10
65	0.1	1	0	28	3
65	0.1	10	0	28	0
65	0.5	1	0	18	6
65	0.5	10	0	20	3
100	0.1	1	0	23	3
130	0.1	1	0	8	3

[1] Inoculum added to treating solutions to produce indicated concentration. After the inoculum was heat treated and cooled, it was applied to fresh cut surfaces of roots. Growth recorded after 7 days at 80° F.

[2] After 7 days at 60° F. Data based on 4 replicates of 10 roots each.

Control of soft rot and black rot was good with 1-percent SOPP applied in 25- and 50-percent water-wax emulsions; but in 100-percent water-wax emulsion, control was reduced (table 10). Other workers reported that black rot was not controlled when SOPP was applied in wax (19). Increasing SOPP to 2 percent in the 100-percent water-wax emulsion restored control to nearly the level obtained with 1-percent SOPP in lower concentrations of water-wax emulsion.

Application of SOPP, at concentrations varying from 0.4 to 1.5 percent in water solutions, by dip or spray reduced soft rot to 2 percent or less in nine tests in which nontreated roots developed from 1 to 26 percent, and averaged 10 percent, soft rot (tables 11 and 13). Black rot was reduced 75 percent or more (tables 12 and 13). Control of these diseases was slightly better with 0.8- to 1.0-percent SOPP treatments than with 0.4- to 0.6-percent treatments (tables 11 and 12). Chemical injury and discolorations were noticeable on roots treated with 1.3- to 1.5-percent SOPP solutions, even when rinsed. Very few roots treated with 1.0-percent or less SOPP developed noticeable discoloration, and rinsing reduced this so that it was difficult to distinguish treated from nontreated roots. Additional tests are needed to determine whether rinsing will control discoloration without the addition of sulfite.

A brief rinse with one nozzle reduced residues of SOPP about 50 percent in most tests (tables 11 and 13). Addition of a second nozzle for rinsing reduced residues still more. Rinsing with one or two nozzles did not measurably alter the control of soft rot or black rot.

Soft rot was reduced 60 to 100 percent by treating roots with 0.5- or 1.0-percent solutions of SOPP and rinsing before packaging in perforated polyethylene bags (table 14). Roots held at 75° F. developed less decay than roots held at 60°, which supports the

TABLE 10.--Effect of concentration of sodium o-phenylphenate and water-wax[1] emulsion on control of soft rot and black rot of Porto Rico sweetpotatoes

Treating solution	Soft rot at bruises[2]	Soft rot at breaks[2]	Black rot[3]
	Percent	Percent	Percent
Check (water)......................................	40	13	100
1-percent SOPP in water............................	0	0	0
1-percent SOPP in 25 percent water-wax emulsion.....	0	0	0
1-percent SOPP in 50 percent water-wax emulsion.....	0	0	0
1-percent SOPP in 100 percent water-wax emulsion....	20	0	[4] 100
2-percent SOPP in 100 percent water-wax emulsion....	3	0	0

[1] Manufactured for color-waxing sweetpotatoes. Usually mixed with about 3 parts water for application (i.e. 25 percent).

[2] After 7 days at 60° F.

[3] Inoculum added to treating solutions. Roots sound after soft rot examinations were held 14 days at 80° before observing for black rot.

[4] Growth was slower than for the check treatment.

TABLE 11.--Soft rot and residue on Porto Rico sweetpotatoes as affected by concentration of sodium o-phenylphenate and rinsing[1]

Concentration	Rinse nozzles	Soft rot after 7 days at 60°			Residue as o-phenylphenol	
		Test 1	Test 2	Test 3	Test 1	Test 2
Percent	Number	Percent	Percent	Percent	P.p.m.	P.p.m.
0	0	8	7	14	0	0
	1	-	-	11	-	-
	2	2	-	14	-	-
0.4 to 0.6......	0	0	T	1	1.9	3.4
	1	0	T	T	.7	2.3
	2	0	T	1	.5	1.4
0.8 to 1.0......	0	T[2]	T	0	3.4	5.5
	1	0	T	0	1.8	3.1
	2	0	0	0	1.0	2.6
1.3 to 1.5......	0	-	0	0	-	9.9
	1	-	0	0	-	4.7
	2	-	0	0	-	3.7

[1] Roots treated in 50-gallon dip tank. SOPP as Stopmold B. Data for soft rot represent average of 3 bushels for each treatment and test.

[2] T = trace.

TABLE 12.--Black rot on Porto Rico sweetpotatoes as affected by concentration of sodium o-phenylphenate and rinsing

Concentration	Rinse nozzles	Black rot after storage[1]	
		Test 1	Test 2
Percent	Number	Percent	Percent
0.............	0	27	46
0.............	1	-	40
0.............	2	-	44
.5...........	0	3	8
.5...........	1	6	5
.5...........	2	4	9
1.0...........	0	1	1
1.0...........	1	1	2
1.0...........	2	T[2]	1
1.5...........	0	1	0
1.5...........	1	2	1
1.5...........	2	0	1

[1] Inoculum added to tank prior to treatment. Stored 7 days at 60°, then 15 days at 70° to 80° F. Percentage based on roots not decayed by soft rot for 3 bushel samples per treatment and test. SOPP used as Stopmold B.

[2] T = trace.

TABLE 13.--Soft rot and black rot, and residue following treatment of Porto Rico sweetpotatoes with 1-percent sodium o-phenylphenate by spraying solution

Test[1]	Soft rot			Black rot[2]			Residue as o-phenylphenol		
	Check (water)	SOPP	SOPP rinsed	Check (water)	SOPP	SOPP rinsed	Check (water)	SOPP	SOPP rinsed
	Percent	Percent	Percent	Percent	Percent	Percent	P.p.m.	P.p.m.	P.p.m.
1............	3	0	-	0	0	-	0	6.6	-
2............	7	2	1	0	0	0	-	-	-
3............	22	1	2	2	0	0	0	2.8	1.3
4............	1	2	1	30	T	0	0	3.3	2.7
5[3]...........	26	2	1	0	0	0	-	-	-
6[3]...........	3	T[4]	0	16	1	4	0	7.9	3.0

[1] Roots given commercial handling and grading, treatment applied with water-wax applicator. All data are averages based on 2 or 3 bushel baskets per treatment per test. Tests 1, 2, and 3 made with freshly harvested, noncured roots. Tests 4, 5, and 6 made with cured roots. SOPP used as Stopmold B.

[2] Natural infection; roots held 14 to 21 days at 75° to 80° F. after the initial holding period for soft rot development.

[3] Almost identical results obtained for soft rot with comparable roots shipped to New York, N. Y., from eastern North Carolina and held 7 days at 70° F.

[4] T = trace.

TABLE 14.--Soft rot in packaged Porto Rico sweetpotato roots treated with sodium o-phenylphenate[1]

Concentration of SOPP	Holding temperature	Soft rot
Percent	Degrees F.	Percent
0	60	19
0.5	60	2
1.0	60	4
0	75	5
0.5	75	2
1.0	75	0

[1] Based on 5 replicates of 20 roots each per treatment obtained from a commercial packing house after being washed, graded, and sized for shipment to market.

Roots immersed in treating solutions 30 seconds, drained and packaged wet after a brief rinse, and held 7 days in perforated polyethylene bags.

data for recuring roots (20). In another test, roots were washed, sized, and trimmed to a specified length, treated with 1.0-percent SOPP for 1 minute, rinsed, and packaged in cardboard trays overwrapped with cellophane, which was heat sealed. After 1 week at 60°, no decay was found in 12 packages (48 roots) of treated roots, while 3 roots in 12 comparable packages of nontreated roots developed decay.

In two tests, roots remaining in sound condition for 1 week after treatment were reinjured by pouring from one container to another. These roots developed just as much soft rot as nontreated roots given the same handling.

DISCUSSION

SOPP is relatively nontoxic to warmblooded animals (8), and its commercial use on citrus, pineapples, apples, pears, peaches, and cantaloups has been approved. The research that accompanied such commercialization has served as a guide for testing several formulations, methods of application, and certain other techniques involved in the application of SOPP to sweetpotato roots. Because the other chemicals have not been so thoroughly tested, more work is needed to determine the potential of the promising ones.

Even though a tolerance has been established for residues of o-phenylphenol on sweetpotatoes, many problems still remain in developing commercial methods for treating roots with SOPP. It will be necessary to show that a specific formulation and method of application will provide sufficient decay control to justify the cost of application. This may involve many factors, of which only a few have been tested. The data indicate SOPP at 0.5 to 1.0 percent may be satisfactorily applied as a dip or spray in water solutions or water-wax emulsions. In two shipments to New York, this was partly confirmed. Maintenance of concentration and pH may be problems in commercial treatment. If color is to be added, the problem of whether to add the color with the SOPP will arise. Possibly the color and SOPP could be added with a foam-wax applicator. There should be no problem of maintaining concentration and pH with such a method, because the stock solution from which the ribbon of foam is formed is not diluted by water on equipment or roots and is not contaminated with plant material or other foreign matter. This method of application has been patented (4) but, as far as is known, its decay control has not been established.

In order to make chemical treatment most effective, handling methods may need to be changed. If roots are injured after treatment with SOPP, soft rot develops as readily as in untreated roots. Packaging sweetpotatoes in rigid containers to protect roots from injury after treatment may be desirable.

Decay control with chemicals might be increased by maintaining higher transit and holding temperatures than those used in the tests reported here. Treatment of roots to prevent decay may aid in placing prepackaged sweetpotatoes on the market. This would be practical if decay could be prevented in roots trimmed to fit specific containers. The use of decay-prevention chemicals might prevent loss in roots shipped to canning or processing plants, where they are often held several days before use. Seed potatoes shipped from areas of production might be treated to prevent loss from soft rot and black rot. If such a chemical treatment could control scurf as well as black rot, it might replace mercury compounds in the prebedding treatment of seed roots. This might not reduce sprout growth as much as mercury compounds, and might permit working with a less toxic chemical[2].

For best results with stored roots, treatment should control diseases other than soft rot and black rot such as end and surface rots (Fusarium sp.), charcoal rot (Sclerotium bataticola) and others. A combination of chemicals might be advisable, as is the case with the use of SOPP and diphenyl on citrus (11).

The p-hydroxybenzoate compounds, represented by PKS and PKC in these tests, appear to deserve further attention. These chemicals were developed in Europe and recently have become available in this country (3). The carbamates used in these tests have been selected during screening tests with citrus (28). Only further tests will determine their value for treating sweetpotatoes.

PAC was eliminated from further tests because it was not as effective against soft rot as other chemicals and because of the difficulty of handling such an explosive material.

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[2] A preliminary test has indicated SOPP as a 1-percent dip did not delay sprout growth.

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